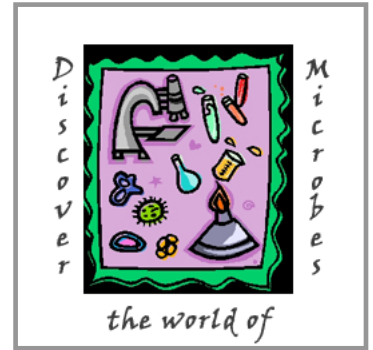


NABT 2006

Microbial Discovery Workshop

Friday, October 13 – Ballroom C
1:30pm – 2:45pm



Creators of the Future: Discovering Microorganisms and Their Roles in Biotechnology

Facilitator: Michelle Suhan-Thomas, Campbell University, Buies Creek, NC

Workshop Outline

- I. Introduction to ASM's Video Podcast and MicrobeWorld.org website.**
- II. *Intimate Strangers*- Episode 10 - A New Age**
This video illustrates the new age of microorganisms where microbes are being used to improve the quality of life. The video presents the use of microbes in genetic engineering and bioremediation and describes new technological advances using electronics and microchips to examine microbial genomes.
- III. Microbial Discovery Activity - Are You My Match?**
In this simple exercise participants will explore the complementarity and the 5'-3" orientation of DNA.
- IV. Microbial Discovery Activity - Taking the Mystery out of DNA- DNA Extractions**
Extracting DNA is one of the first steps for any scientist who practices genetic engineering. In this exercise the methods to extract DNA from cells will be explored. Following this activity, participants should have a better understanding of cell structure and the methods to break open cells and extract DNA.
- V. Presentation of the Microbial Discovery on-line resources.**
Participants in this workshop will receive additional information on teaching resources available at the American Society for Microbiology website.

**Did you use this activity in your classroom?
Please send questions/comments to:**

American Society for Microbiology
Education Department
1752 N Street, NW
Washington, DC 20036
EducationResources@asmusa.org

An Educational Program of



**AMERICAN
SOCIETY FOR
MICROBIOLOGY**

Microbial Discovery Workshop - Sample Lesson Planning Guide

Teacher: _____

Standard: Content A,B,C

Benchmark(s):

Course/Subject:

Taking the mystery out of DNA: Extracting DNA from Strawberries

Anticipatory Set

The Hook

DNA is that biological molecule that is used to discover the killer on CSI or the molecule central to genetically modified foods. DNA is the information inside a cell that is essential for the life of cells and organisms. But, what does DNA look like and how do scientists manipulate it?

Review and Practice:

Students will review the concept of DNA structure and function. Students will need a general understanding of the difference between a eukaryotic plant cell, animal cell, and a prokaryotic bacterial cell. They will need to define prokaryotic, eukaryotic, chromosome, lysate, and precipitate.

Activate Prior Learning:

- Questioning
- Individual work
- Discussions
- Home work
- Group work
- Reciprocal teaching

Value of the Lesson:

The activities provided a hands-on approach to learning about DNA. Students will review cellular structure and the methodologies involved with extracting the chromosomal DNA from a strawberry. The students observe first hand the DNA as it is extracted from the cells.

Objective/Outcome:

- Be able to define: prokaryotic, eukaryotic, chromosome, lysate, and precipitate.
- To understand the difference between a eukaryotic plant cell and animal cell.
- To learn how to break open cells and separate the DNA from other cellular components.

Microbial Discovery Workshop - Sample Lesson Planning Guide

Instructional Delivery: Process

<p>Teacher Processes:... How will the learning be facilitated:</p> <p>To introduce the topic of biotechnology, the Microbe World podcast will be used to facilitate discussion on genetic modification of plants. This will lead to a mini-lecture on how DNA can be extracted from the cells, one of the first steps in genetic modification.</p>	<p>Activities:</p> <ul style="list-style-type: none"> • Mini lecture • Discussion • Thinking skills <ul style="list-style-type: none"> • Analyzing • Synthesizing • Evaluating • Sequencing • Classifying • Generalizing • Prioritizing • Cause-effect • Inferring • Hypothesizing • Planning • Decision making • forecasting • Divergent thinking skills <ul style="list-style-type: none"> • Fluency • Flexibility • elaboration • Independent projects • Simulations • Performance (oral, written, visual) • Research • Drama (role playing) • Problem Based • Socratic dialogue • Field trip
<p>Student Process/Procedures... What will the students do? (Activities)</p> <ul style="list-style-type: none"> - Students will participate in discussions on biotechnology, cell structure, and DNA extraction. - Students will perform a DNA extraction activity. - Students will document observations and results from the extraction and answer a set of questions related to the activity (Student Data Sheet). 	
<p>Guided Practice (Check for understanding)</p> <ul style="list-style-type: none"> - The Student will turn in a Student Data Sheet for grading. 	

- Cooperative Learning
 - Jig saw
 - Think/pair/share
 - Walk about
 - Graffiti board
 - 3 step interview
 - Round table
 - Para phrase
 - Academic controversy
 - Simple square
 - 4 corners
- Graphic Organizers
 - Word web
 - Venn diagram
 - Mindmap
 - Classification grid
 - Sequence chart
 - Flow chart
 - Fish bone
 - Right angle
 - Spectrum
 - Pie chart
 - Graphs
 - Agree/disagree chart
- Demonstration
- Manipulations
- Lab-work

Microbial Discovery Workshop - Sample Lesson Planning Guide

Summary/Closure:

Clearly articulate (student/teacher)

What was learned? How will it be applied?

Student will learn the structure of DNA and now have it connected to an hands on DNA extraction. Student will now have a better understanding of what DNA looks like and how scientists are able to isolate it and work with it.

Assessment and Evaluation of Lesson:

- The Student will turn in a Student Data Sheet for grading.

- | | |
|---------------------|--------------------------|
| • Oral presentation | • Learning logs |
| • Performance | • Journal |
| • Rubric | • Performance assignment |
| • Exhibition | • Interview |
| • Tests | • Contract |
| • Portfolio | • Observation |
| • Project | • Checklist |
| • Demonstration | |

Homework:

- Students will need to complete the Student Data Sheet. This can be done in class if time permits or the questions could be done at home.
- Homework assignments could be developed: Student could be assigned reading material from their textbook on DNA and DNA structure. They could be assigned the task of investigating and writing a report on genetic modification of plants.
-

Technology-Utilization:

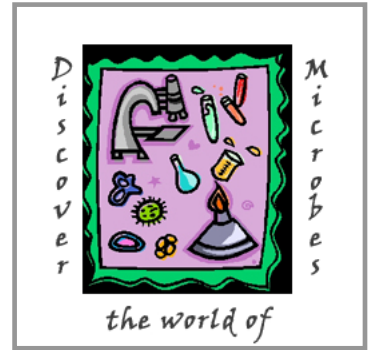
- The podcast will be used to introduce the topic.
- Materials: Podcast, Text is optional, Handouts (data sheets and procedures), and general laboratory equipment (see activity sheet).

Materials:

- | | |
|-----------------|--------------|
| • Text | • Newspapers |
| • Supplementary | • Handouts |
| • Magazines | • Equipment |
| • Worksheets | • Computers |
| • Maps | • Software |
| • Calculators | • Other |

Microbial Discovery Activity

Taking the Mystery Out of DNA: Extracting DNA From Strawberries



Abstract

Students will explore how scientists isolate deoxyribonucleic acid, DNA, from the strawberry. The activity provides the students with a hands-on approach to DNA isolation. They will learn how cells can be broken open and how the DNA can be separated from the rest of the cellular biological molecules. Although students may recognize DNA as being the genetic material and that it can be used in forensics to identify a killer, most are not exposed to what DNA looks like. This activity brings DNA to life!

Intended Audience

K-4	
5-8	X
9-12	X

Learning Objectives

At the completion of this activity, the students will be able to:

- To explain the difference between a prokaryotic and eukaryotic cells.
- To explain some differences in cellular structure between animal cells and plant cells.
- To explain the structure of deoxyribonucleic acid, DNA.
- To be able to explain and then carry out the breakage of cells to release cellular constituents.
- To explain and then carry out the separation of DNA from other cellular components.

Necessary Student Background

Students will need a general understanding of the structure of DNA and cellular structure.

Keywords

biotechnology, recombinant DNA technology, genetic engineering, deoxyribonucleic Acid (DNA), plant cells, extraction, precipitate, hydrogen bonding.



General Information

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Department of Biological Sciences
Buies Creek, NC 27506
suhan@campbell.edu

National Science Education Standards Addressed

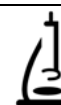
Standard A: Science as Inquiry- In completion of this activity, students will investigate cell structure and the methods to extract DNA.

Standard B: Physical Science- In completion of this activity, students must consider the basic chemistry of the DNA molecule and how that relates to the DNA extraction processes. In particular, students will learn about hydrogen bonding.

Standard C: Life Sciences- In completion of this activity, students will examine eukaryotic cell structure and investigate the function and the structure of DNA in living organisms. Students explore DNA as being the molecular basis of heredity.

Activity Specifications

Classroom setting	X
Requires special equipment	X
Uses hands-on manipulatives	X
Requires mathematical skills	
Can be performed individually	X
Requires group work	
Requires more than one (45 min) class period	
Appropriate for special needs student	X



Teacher Handout

Taking the Mystery Out of DNA: Extracting DNA from Strawberries

Class Time

Approximately 45 minutes of class time are required.

Teacher Preparation Time

Teacher preparation time will vary depending on approach. Generally, less than one hour of preparation time is required in order to acquire the strawberries and to set up the materials for the students.

Background

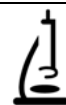
Biotechnology & Applications:

Biotechnology is the use and manipulation of living organisms to provide a practical outcome or product that should benefit mankind. Biotechnology is a broad term that may include different laboratory procedures and applications. Modern biotechnology often involves the manipulation of the deoxyribonucleic acid, DNA from living organisms. These applications that involved the manipulations of DNA is referred to as recombinant DNA technology or genetic engineering. Recombinant DNA technology generally involves the isolation of the DNA or genes, the alteration of genes, and the ability to move genes from one organism to another.

What are some practical applications of biotechnology? Recombinant DNA technology allows for the production of medicine. One example is human insulin that is used to treat diabetes. The human insulin gene can be isolated from the human chromosome and then inserted into a bacterium. The bacteria will produce the insulin protein that can then be isolated and purified and ultimately used as a drug to treat diabetics.

Recombinant DNA technology may be used to study and treat human diseases. Scientists are working to identify the genes that are responsible for genetic diseases. Individual with a particular disorder may have a mutation or change in their DNA leading to the disease. **Gene Therapy** is a modern approach to fix the mutant genes inside the human. Cells from the patient are isolated. These cells are manipulated so that they take in the normal gene and the normal gene will replace the faulty gene. The genetically engineered cells are placed back into the patient. The patient will now carry cells with the corrected gene.

Genetic engineering is used in agriculture to hopefully improve the productivity of crops. Plants can be genetically engineered to carry genes that result in resistance to insects or improved growth characteristics. The use of recombinant DNA technology is integrated in many aspects of our everyday lives even though we do not always recognize it. Even the vegetables that you eat may be genetically modified foods.



In order to perform recombinant DNA technology or simply to study genes, one must isolate the DNA from cells. In this exercise, your students will explore how DNA can be isolated from cells by a process referred to as a **DNA extraction**.

DNA Extraction from Strawberries:

When a scientist needs a source of DNA, it must be extracted from the cells that are being studied. In this exercise students will extract DNA from strawberries. This exercise allows the students to visualize the chromosomal DNA thereby reinforcing the concepts learned about DNA structure.

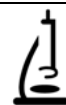
The chromosomal DNA is the blueprint for an organism determining what that organism will look like. DNA contains all the genetic information that forms the basis of inheritance and directs the making of proteins. The strawberry is a eukaryotic plant cell containing the chromosomal DNA inside the nucleus. In order for one to be able to extract and visualize the DNA, one must have a large quantity of DNA inside the test tube. This means that the DNA must be extracted from a large number of cells. A single strawberry contains many cells providing a good cellular sample for DNA. The strawberry is octoploid meaning that it contains eight copies of each type of chromosomes and this provides a large amount of DNA that can be isolated from one or two strawberries.

What are the basic steps for extracting DNA from eukaryotic cells such as a plant cell? The entire process can be divided into three basic steps. There are special procedures and reagents that are used to accomplish each of these steps. The three steps include: “lysing” the cytoplasmic membrane (also called the plasma membrane), lysing the nuclear envelope, and separating out the DNA from the rest of the cellular material.

First the cytoplasmic membrane surrounding the plant cell must be disrupted or broken open. The process of “breaking open” the cell is referred to as “lysing the cell”. Once the cytoplasmic membrane is lysed the nucleus is released. Since the nuclear envelope surrounds the DNA, this membrane must also be broken open to completely release the DNA. Lysing the plasma membrane and the nuclear envelope can be accomplished together since both are membranes with a similar composition of lipids and proteins. Detergents are useful reagents that assist with disrupting the membranes. The molecules that make up the detergent interact with the lipids and proteins and act to pull them away from the membrane. Therefore one can easily disrupt membrane structure to lyse the cytoplasmic membrane and nuclear envelope by manually squashing the strawberry and adding a detergent.

The strawberry is a plant cell and therefore like other plant cells, the strawberry cell contains a cell wall composed of cellulose located outside of the plasma membrane. However, one benefit of using a ripened strawberry is that specialized steps to break down the cell wall are unnecessary. As a strawberry ripens it produces pectinases and cellulases, enzymes that break down the cell wall. The ripened fruit does the work of breaking down the cell wall structure making it easier for you to break open the cells and extract the chromosomal DNA.

Following the lysing of the plasma and nuclear membranes, a cell lysate (extract) has been generated which contains the released DNA along with all the other cellular components. The next step is to separate out the DNA from all of the other molecules of the cell. The DNA is precipitated and thereby separated by using ethanol and salt. Recall that the DNA molecule is double stranded and each strand is composed of a phosphate-sugar backbone (the sides of the ladder) with the nitrogen containing bases that hydrogen bond with the bases from the other strand (the rungs). The outer phosphate groups on the phosphate backbone provide negative charges that can hydrogen bond with water molecules. The ability of DNA to hydrogen bond to water molecules allows DNA to be soluble in water. Ethanol carries a hydroxyl group that is capable of forming hydrogen bonds with



water. When ethanol is added to the cell lysate, the ethanol forms hydrogen bonds with water molecules and pulls the water away from the DNA. The DNA is insoluble in ethanol. The negative charges in the DNA will interact with the charges from the salt. Since the DNA is no longer interacting with water molecules, it aggregates with other DNA molecules and salt thereby precipitating or separating out from the rest of the cellular components. Following the addition of the ethanol and salt, the DNA precipitates and appears as a stringy white substance.

Materials and Equipment

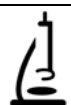
- Frozen or fresh strawberries
- Plastic baggie: Use a heavy duty zip lock baggie. The freezer storage zip lock bags work best because they will not tear as easily.
- 1 test tube (or small beaker) per extraction
- 1 test tube rack (is a test tube is being used) per extraction or shared)
- 1 funnel per extraction
- 1 small piece of cheesecloth per extraction
- 10 ml of DNA extraction buffer per extraction
- a glass cylinder or 10 ml pipette to measure out the DNA extraction buffer.
- Ethanol in a squirt bottle (keep on ice).
- 1 Glass rod or wooden stick per extraction

Methods

Instructor Preparation for the Activity:

1. The instructor may allow the students to obtain their own strawberry and plastic bag. However, if time constraints in class are present, the instructor can place 1-2 strawberries in a plastic bag for each student in advance. These can be kept in the freezer until the day of class. Thaw before using!
2. Prepare the DNA extraction buffer. 1000 ml will be enough for 100 students.
 - 100 ml of shampoo without conditioner (3/8 cup). [50 ml of dish detergent can substitute for the shampoo].
 - 15 g sodium chloride (2 teaspoons).
 - 900 ml of water
3. The DNA extraction buffer may be placed at one location and the students can measure out the DNA extraction buffer and add it directly to their bag with the strawberry. Alternatively, the DNA extraction buffer could be dispensed into tubes prior to the start of class and handed to each student.
4. Prior to the start of class, cut the cheesecloth so that it fits over the edge of the funnel. The cheesecloth should be 2 layers thick.
5. The ethanol should be above 90%. It is easiest to have the ethanol in a squirt bottle or dispensed in dropper bottles. They may be kept on ice in one location of the room.

The student handout provides detailed background information for the student. This activity can be easily modified to increase inquiry based activities by eliminating the introduction and discussing



the concepts with the students. The students could examine cell structure and then be presented with the question of how they would proceed to extract the DNA.

Safety Precautions

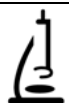
The students should practice standard good laboratory techniques. Goggles should be used.

Microorganisms

None.

Assessment

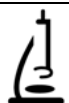
- Students can complete the Student Data Sheets.
- Students can compose an independent formal lab write up.
- Have students write quiz questions pertaining to the lab and quiz other members of their class. The teacher may also use the student-generated questions to create a test or quiz.
- Journal.
- Presentation (verbal or computer –based).
- Create a concept map that describes the lab and its results.
- Group discussion.
- Use a rubric to assess any of the suggestions above.



Appendix

This activity has been a modified activity from:

Biology, Exploring Life, Diane Sweeney Labs, Pearson Education
http://www.carnegieinstitution.org/first_light_case/horn/DNA/berrydna.pdf



Student Handouts

Taking the Mystery out of DNA: Extracting DNA from Strawberries

Student Name: _____

Introduction

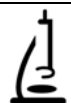
Biotechnology is the use and manipulation of living organisms to provide a practical outcome or product that should benefit mankind. Modern biotechnology often involves the manipulation of the deoxyribonucleic acid, DNA from living organisms. These applications that involved the manipulations of DNA is referred to as recombinant DNA technology or genetic engineering. Recombinant DNA technology generally involves the isolation of the DNA or genes, the alteration of genes, and the ability to move genes from one organism to another. Biotechnology is used for the production of certain medicines, for the genetic modification of plants to become better producers or disease resistant, for forensics to identify a murderer, and for learning about and treating human disease.

When a scientist needs a source of DNA, it must be extracted from the cells that are being studied. In this exercise you will extract DNA from strawberries using a DNA extraction protocol. The chromosomal DNA is the blueprint for an organism determining what that organism will look like. DNA contains all the genetic information that forms the basis of inheritance and directs the making of proteins. The strawberry is a eukaryotic plant cell containing the chromosomal DNA inside the nucleus.

In order for one to be able to extract and visualize the DNA, one must have a large quantity of DNA inside the test tube. Have you ever been walking through a forest only to discover that you have walked into a spider web? The strands in the web are very thin and not easy to detect until you are very close to it. In the same way, DNA is extremely thin (much thinner than the individual strands of spider web). However, if you were take thousands of those thin strands and put them together they would become more visible. In the same way, the only way for you to observe DNA is to have a very large quantity of the DNA. This means that the DNA must be extracted from a large number of cells. A single strawberry contains many cells providing a good cellular sample for DNA. The strawberry is octoploid meaning that it contains eight copies of each type of chromosomes and this provides a large amount of DNA that can be isolated from one or two strawberries.

What are the basic steps for extracting DNA from eukaryotic cells such as a plant cell? The entire process can be divided into three basic steps. There are special procedures and reagents that are used to accomplish each of these steps. The three steps include: “lysing” the cytoplasmic membrane (also called the plasma membrane), lysing the nuclear envelope, and separating out the DNA from the rest of the cellular material.

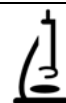
First the cytoplasmic membrane surrounding the plant cell must be disrupted or broken open. The process of “breaking open” the cell is referred to as “lysing the cell”. Once the cytoplasmic membrane is lysed the nucleus is released. Since the nuclear envelope surrounds the DNA, this membrane must also be broken open to completely release the DNA. Lysing the plasma membrane and the nuclear envelope can be accomplished together since both are membranes with a similar composition of lipids and proteins. Detergents are useful reagents that assist with disrupting the membranes. The molecules that make up the detergent interact with the lipids and proteins and act



to pull them away from the membrane. You can easily disrupt membrane structure to lyse the cytoplasmic membrane and nuclear envelope by manually squashing the strawberry with your hands and adding a detergent.

The strawberry is a plant cell and therefore like other plant cells, the strawberry cell contains a cell wall composed of cellulose located outside of the plasma membrane. However, one benefit of using a ripened strawberry is that specialized steps to break down the cell wall are unnecessary. As a strawberry ripens it produces pectinases and cellulases, enzymes that break down the cell wall. The ripened fruit does the work of breaking down the cell wall structure making it easier for you to break open the cells and extract the chromosomal DNA.

Following the lysing of the plasma and nuclear membranes, a cell lysate (extract) has been generated which contains the released DNA along with all the other cellular components. The next step is to separate out the DNA from all of the other molecules of the cell. The DNA is precipitated and thereby separated by using ethanol and salt. Recall that the DNA molecule is double stranded and each strand is composed of a phosphate-sugar backbone (the sides of the ladder) with the nitrogen containing bases that hydrogen bond with the bases from the other strand (the rungs). The outer phosphate groups on the phosphate backbone provide negative charges that can hydrogen bond with water molecules. The ability of DNA to hydrogen bond to water molecules allows DNA to be soluble in water. Ethanol carries a hydroxyl group that is capable of forming hydrogen bonds with water. When ethanol is added to the cell lysate, the ethanol forms hydrogen bonds with water molecules and pulls the water away from the DNA. The DNA is insoluble in ethanol. The negative charges in the DNA will interact with the charges from the salt. Since the DNA is no longer interacts with water molecules, it aggregates with other DNA molecules and salt thereby precipitating or separating out from the rest of the cellular components. Following the addition of the ethanol and salt, the DNA precipitates and appears as a stringy white substance.



Activity

Safety Considerations

Use standard safe laboratory practices. For the safety of your eyes wear goggles.

Materials Checklist

- 1-2 strawberries in a plastic bag
- 1 test tube
- 1 test tube rack
- funnel
- small piece of cheesecloth
- 10 ml of DNA extraction buffer
- Ethanol in a squirt bottle (keep on ice)
- Glass rod or wooden stick

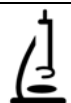
Procedure

A. Lysing the cells and nuclei:

1. Obtain one clear plastic bag, 1-2 strawberries, a test tube, test tube rack, funnel, piece of cheesecloth, glass rod or wooden stick, and approximately 10 ml of DNA extraction buffer.
2. Place 1-2 strawberries inside the plastic bag. Use your fist to **gently** mash the bagged strawberries for 1 minute. *This will begin to mechanically break open the cells.*
3. Add approximately 10 ml of the DNA extraction buffer to the bagged strawberry. Press the bag so that the air is removed and then seal the bag. Using your fist, gently mash the strawberry in the extraction buffer for 1 minute. *This will continue to lyse the cells and to break open the nuclei.* The extraction buffer contains shampoo (a source of detergent), salt, and water.
4. Place the cheesecloth onto the funnel to make a filter. Now place the funnel (with the cheesecloth) onto the test tube. Filter the strawberry extract by pouring it onto the cheesecloth and allowing the liquid material to enter into the test tube.
5. **Once the test tube is about 1/4 filled stop.** Remember to close your zip lock baggie before setting it down and to the side. You may now remove the funnel. *The filtration step is necessary to trap the larger cellular materials (broken cell walls, disrupted membrane, organelles) onto the cheesecloth. The DNA extract is filtered into the test tube.*

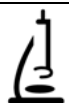
B. Precipitating and spooling the DNA:

1. Obtain an ice-cold ethanol squirt bottle. Gently add the cold ethanol to the cell extract by slowly dripping the ethanol down the side of the tube. The ethanol should layer on top of your filtered cell extract. You should be able to see *two distinct layers*. The ethanol will be on the top and the cell extract below. Watch at the interface of these two layers. *The ethanol will assist in precipitating the DNA. You should begin to see white stringy material (mucous like) forming at the interface of the ethanol and extract. This is DNA.*
2. As you are observing the interface, insert a wooden stick or glass rod through the ethanol layer until it reaches the interface of the ethanol and extract. Place the rod just below the interface and twirl or turn the rod. The DNA should attach to the rod and as you



twirl it the DNA will wind around the rod. As the DNA winds around the rod it may appear something like white cotton candy.

3. Wash your hands and clean up your laboratory bench putting all materials in the proper place. You may now discard the strawberry extract in the bag into the garbage. Answer the questions on the student data sheet.





M.D.A. Lesson Evaluation

American Society for Microbiology
1752 N. Street N.W.
Washington, D.C. 20036

Lesson Title:

Grade Level:

Course Title:

Teacher's Name:

Number of Students:

School District and Address:

Preparation

Yes

No

Notes:

Are the set-up procedures too complex for the purpose of the lesson?

Were the materials easy to acquire?

Did you have all applicable materials and equipment in your lab?

How much time did the lesson take to set up?

In class time?

Out of class time?

Lesson Design

Exceptional

Good

Poor

Unsatisfactory

Please rate the introductory activities.

Please rate the lesson/project

Please rate the experiment, in regards to student interest.

Handouts

Exceptional

Good

Poor

Unsatisfactory

Please rate the effectiveness of the teacher handout?

Please rate the effectiveness of the student handout?



M.D.A. Lesson Evaluation

American Society for Microbiology
1752 N. Street N.W.
Washington, D.C. 20036

Assessment

Yes

No

Notes:

Can this lesson can be accomplished in the amount of time indicated by the author?

If no, how much time did the lesson take?

Are you planning any follow up activities?

If so, what assessments or reviews will you be using? (tests, essay, discussion, etc.)

How were the national science standards addressed in this lesson?

General

Yes

No

Was this lesson effective in conveying a particular concept/activity?

Would you teach this lesson again in future years?

Would you recommend this lesson to a friend?

How would you change this lesson if you were to teach it again?

Podcast

Yes

No

Was the podcast appropriate for the intended audience?

Was the podcast clearly linked to the lesson objectives?

Was the lesson enhanced by the use of the podcast?